First in-situ measurements of Fe3+/Fetot for oxides and silicates included in natural diamonds with Synchrotron Mössbauer Source

FIRST IN-SITU MEASUREMENTS OF Fe^{3+}/Fe_{TOT} FOR OXIDES AND SILICATES INCLUDED IN NATURAL DIAMONDS WITH SYNCHROTRON MÖSSBAUER SOURCE

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Diamond is the paramount phase to understand the evolution and the physico-chemical condition of the deep portions of the Earth's mantle, mainly because: (i) it is the stable phase through which carbon is stored in the deep mantle for long geologic time; (ii) it does contain and preserve different types of inclusions (fluid, mineral, etc.); (iii) it is the only material sampling the mantle to depths of 800 km (e.g. Harte, 2010), although the majority of the mined diamonds worldwide derive from shallower depth (150 to 250 km). The study of mineral inclusions trapped in diamonds allows the retrieval of different pieces of information about the Earth's interior and its active geodynamics, providing important clues on the initiation of subduction processes (Shirey & Richardson, 2011; Smart et al., 2016), tracking the transfer of material through the mantle transition zone (Stachel et al., 2005; Walter et al., 2011), recording the timing of ingress of fluids to the continental lithosphere (e.g. Shirey et al., 2004), preserving carbonatitic fluid that trigger deep mantle melting (e.g. Schrauder & Navon, 1994; Kopylova et al., 2010), providing samples of primordial noble gases (e.g. Ozima & Igarashi, 2000), and capturing the redox state of the mantle (e.g. Rohrbach & Schmidt, 2011).

Unfortunately the majority of the techniques used so far to study the mineral inclusions are destructive. It is only in the last decade that the studies on inclusions in diamond have started to use non-destructive techniques, providing new information which would otherwise be lost using earlier destructive techniques. Such an example is the rim fluids around inclusions in diamonds. In this study we present details of the experimental setup on the determination of Fe^{3+}/Fe_{tot} ratios of mineral inclusions whilst still within the diamonds by a non-destructive approach using the Synchrotron Mössbauer Source (SMS; Potapkin et al., 2012) at the Nuclear Resonance beamline

ID18 (Rüffer & Chumakov, 1996), European Synchrotron Radiation Facility (ESRF), Grenoble. The extremely small X-ray spot size (10 × 15 μm^2) is perfectly suited for our purposes as some inclusions are smaller than 30-50 μm and the Fe^{3+}/Fe_{tot} variation over the same inclusion cannot be performed by using standard laboratory radioactive sources because of the larger beam size. The average collection time for thicker inclusions (~ 200 μm) was 2 hours per spectrum, whilst the smallest inclusion (~ 30×30×30 μm^3) required a collection time of approximately 10-12 hours in order to get a spectrum with nicely distinguishable features and a high signal-to-noise ratio. In general, application to a suite of silicate and oxide inclusions in diamonds produced comparable results with respect to those obtained using conventional Mössbauer sources (e.g. McCammon et al., 2004).

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